FI-199

I. EXECUTIVE SUMMARY

a. Cadmium, Mercury, and Selenium Contamination in Diving Ducks and Benthic Prey from Wintering Sites at San Pablo and Suisun Bays, CA, and Breeding Grounds at Ruby Lake NWR, NV. Dr. John Takekawa and Dr. Keith Miles, USGS California Pacific Science Center; Mr. James Haas and Dr. Steven Schwarzbach, USFWS Sacramento Field Office; Dr. Gary Heinz and Dr. David Hoffman, USGS Patuxent Wildlife Research Center.

b. **Project Description and Primary Biological/Ecological Objectives.**

The natural wetlands of San Francisco Bay ecosystem have been diked or degraded for agricultural, municipal, and industrial uses beginning in 1850. A recent agreement between the federal government and the state of California identified the crisis in the estuary between human and wildlife needs through a proposed planning process (CALFED) that would continue providing municipal water, maintain the levee system, and manage for the natural resources of the estuary. However, few studies have been conducted in the northern region of the ecosystem to address the water quality concerns with relation to large migratory bird populations that are dependent on the estuary. Additionally, introductions of exotic species such as the Asian clam have changed available food resources for migratory birds. Recent studies indicate that the Asian clam is increasing exponentially in the North Bay area and it has higher levels of contaminants than native species, effectively tripling the concentration of selenium in shellfish. Elevated contaminant levels in diving ducks such as canvasbacks, lesser and greater scaup, and surf scoters, heavily dependent on shellfish and widely distributed in the San Francisco Bay ecosystem, have also been reported. These reports suggest that contaminants are biomagnifying in the estuary food chain.

This study will sample the tissues of wintering populations of canvasbacks, scoters, and scaup in San Pablo and Suisun Bays for selenium, mercury, and cadmium. Livers and breast muscle of diving ducks will be analyzed for selenium and for total and methyl mercury, and their kidneys will be analyzed for cadmium, and results compared to earlier studies. Blood samples will be analyzed for all three metals to determine whether non-lethal blood samples can be used for future assessments of contaminant exposure. Duck stomach contents and field collected native and non-native benthic invertebrates will be analyzed for the same contaminants to identify the source and specific pathway for bioaccumulation through the benthic community, and to determine dietary concentrations and ratios of cadmium, mercury, and selenium. Biological effects will be evaluated by examining: 1) body condition of field collected birds; 2) overwinter survival of radio-marked individuals; and 3) migratory success and cross-seasonal productivity of radio-marked canvasbacks that winter in San Francisco Bay and nest at Ruby Lake National Wildlife Refuge, Nevada. Adverse effects detected in the field studies will be verified by laboratory dosing studies using mallard ducks. Dietary concentrations of mercury, selenium, and cadmium (based on concentrations measured in field collected prey and forage items) will be fed singly and in combination to evaluate effects on survival, body condition, and reproductive success, and to estimate No Observed Adverse Effect Levels in the ducks diets.

c. **Approach/Tasks/Schedule.**

The project will be conducted over a period of four years beginning in the fall of 1997 as a series of integrated field and laboratory activities managed by Dr. Schwarzbach, Dr. Takekawa, and Dr. Heinz. Status reports will be issued annually, with the final report due in the fall of 2001.

d. **Justification for Project and Funding by CALFED.**

The data obtained from this study will: 1) enable better evaluation of permissible levels of discharge for cadmium, mercury, and selenium, and assist in determining relative priorities in the control of these pollutants entering

the bay through permitted and unpermitted discharges; 2) aid the San Francisco Bay Area Wetlands Ecosystem Goals Project and CALFED in identifying areas where direct management options for improving habitats and water quality in the estuary are most feasible based on contaminant concentrations and effects; 3) allow better evaluation or determination of clean up levels for numerous CERCLA sites around the margins of San Francisco Bay; 4) focus efforts to evaluate risks to other benthic foragers such as green sturgeon; and 5) help assess baseline risks of current cadmium, mercury, and selenium inputs to the delta for species perhaps at greatest hazard from these bioaccumulative contaminants.

e. Budget Costs and Third Party Impacts.

The project will be completed at a total cost to CALFED of $1,246,021, with in-kind services equivalent to $446,100 provided by USGS. There are no third party impacts.

f. Applicant Qualifications.

The project applicants are highly qualified to conduct the project proposed. All are career agency biologists with extensive training and education related to waterfowl and estuarine ecology and the effects of contaminants on biological systems, and all have technical and/or managerial experience in field and laboratory studies of the type proposed. Drs. Takekawa and Miles are intimately familiar with the ecology of the San Francisco Bay estuary and its unique contaminant issues; Dr. Schwarzbach is widely recognized as an expert in mercury contamination in San Francisco Bay, particularly as it affects birds; and Drs. Heinz and Hoffman have nearly 60 years combined experience conducting toxicological studies in the laboratory.

g. Monitoring and Data Evaluation.

The investigators will participate in integrated semi-annual workshops with other CALFED project investigators examining mercury contamination in the Sacramento-San Joaquin system to review and share preliminary data. In addition, status reports, prepared in cooperation with other investigators, will be submitted at the end of years 1-3 of the study. Data will be evaluated and analyzed using standard parametric and nonparametric techniques as appropriate. The final report will be submitted to a peer reviewed journal for publication, with the final report prepared in the format of the target journal.

h. Local Support/Coordination with Other Programs/Compatibility with CALFED Objectives.

This project proposal is one of ten proposals examining various aspects of mercury contamination in the San Francisco Bay-Delta that are being submitted in coordination between numerous agencies and public institutions, including: the U.S. Geological Survey, the U.S. Fish and Wildlife Service, the California Division of Mines and Geology, the State Water Resources Board and several Regional Water Quality Control Boards, the Contra Costa County Public Works Department, Lawrence Berkeley Laboratory, and the University of California at Davis. The goal of these organizations is to address significant mercury - related issues while avoiding duplication of effort. This project specifically supports the CALFED objectives of providing good water quality for all beneficial uses and improving and increasing aquatic and terrestrial habitats and improving ecological functions in the Bay-Delta to support sustainable populations of diverse populations of diverse and valuable plant and animal species. The project will address uncertainties regarding the biological effects of mercury, selenium, and cadmium contamination on survival and reproduction of benthic-foraging ducks. Successful completion of the project will aid significantly in setting or evaluating water and sediment contaminant criteria, and facilitate management decisions regarding source control and restoration.

Cadmium, Mercury, and Selenium Contamination in Diving Ducks and Benthic Prey from Wintering Sites at San Pablo and Suisun Bays, CA and Breeding Grounds at Ruby Lake NWR, NV.

by

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RFP Project Group 3: Other Services

III. PROJECT DESCRIPTION

A. Project Description and Approach

The goal of this study is to evaluate the potential adverse effects, including possible interactive effects, of dietary mercury, selenium, and cadmium on the survival and reproduction of wintering canvasbacks, scoters, and scaup in San Pablo Bay and Suisun Bay; and relate the occurrence of adverse effects to specific locations and seasons, and to the abundance of non-native benthic prey species, which seem to bioaccumulate contaminants to higher concentrations than native species in the estuarine food web. Six tasks have been developed to accomplish the project goal as follows:

Task 1. *Estimate the movements and over-winter survival of radio-marked scaup, scoters, and canvasbacks in the estuary in relation to species, location, food preferences, and estimated risk of exposure.*

Scaup and scoters will be captured in October or November during the first two years of the study and radio-marked with implanted transmitters. To ensure an adequate sample size, 25 adult ducks will be captured and marked in each bay (50 birds) during each year. Over a two-year period, beginning in the spring of the first year, 100 female canvasbacks (50 per year) will be radio-marked on their breeding grounds in the Ruby Lake National Wildlife Refuge. The birds will be tracked to the San Francisco Bay estuary, their major wintering area on the basis of band returns (RLNWR, unpubl. data), where their movements and survival will be evaluated. Survival estimates will be obtained by relocating the birds on a weekly basis and estimating a Kaplan-Meier survival rate (Pollock *et al.* 1989, White and Garrott 1990). Movements and home ranges will also be examined. Relative differences in survival of each species will be evaluated based on site, season, and contaminant concentrations in prey or forage and in tissue as determined in Tasks 2 and 3.

Task 2. *Examine the foraging ecology and food preferences of canvasbacks, scoters, and scaup wintering in San Pablo and Suisun Bays in relation to mercury, selenium, and cadmium concentrations in their prey.*

Following telemetry studies the first year, a sample of ten ducks per species will be collected in each bay in early (Oct-Dec) and late (Jan-Mar) winter (total=120 ducks/year) for two years. Duck stomach contents will be analyzed to determine the percentages of native and non-native bivalve molluscs and vegetation present in diets. A subsample of the stomach contents will be chemically analyzed for cadmium, total mercury, methyl mercury, and selenium. Percentages of prey or forage items in diets and concentrations of contaminants in stomach contents and tissues will be compared by species, site, and season with multivariate analysis of variance (Johnson and Wichern 1988, SAS Institute 1990).

A square kilometer sampling grid will be established in San Pablo Bay and Suisun Bay. Core samples of invertebrates will be taken from grid squares (minimum 3 cores per square) used by diving ducks as determined by radio telemetry or aerial surveys. Core samples will be taken in early and late winter for two consecutive years. Bivalve mollusks will be divided into native and non-native categories. In addition, samples of appropriate vegetation, as determined by stomach content analyses, will be collected from each grid as available. These surrogate food items will be analyzed for cadmium, selenium, total mercury, and methyl mercury. Results will be compared by category, site, and season. Results will also be compared to esophageal content analyses.

The determination of food preferences will examine both differences between species and between bays, measure contaminants in prey and forage samples from both bays, and measure contaminants in stomach contents of field-collected birds to evaluate relative risk of exposure. Differences in contaminant

concentrations between native and non-native benthic prey species will also be evaluated. Diet preferences will be compared with compositional analysis (Atchison 1986, Aebischer et al. 1993, Warnock and Takekawa 1995), a multivariate analysis of variance approach to examine proportion data. The results will be used in Task 5.

Task 3. *Determine concentrations of methyl and total mercury and selenium in liver and breast muscle tissue, cadmium in kidney tissue, and all three metals in blood of field collected ducks; evaluate body condition.*

Ducks collected for Task 2 will have selected tissues analyzed for contaminants. Livers and breast muscle will be analyzed for total mercury, methyl mercury, and selenium. Kidneys will be analyzed for cadmium. Blood will be analyzed for all four contaminants. Analytical results will be compared by species, location, and season. Body condition of each collected duck will be evaluated for effects such as mass wasting syndrome and feather loss associated with selenium toxicosis. In addition, liver samples will be archived for possible determination of selenium speciation.

Task 4. *Determine mercury and selenium depuration rates, migratory success, and cross-seasonal productivity of radio-marked canvasbacks that spend the winter in San Francisco Bay estuary and nest in the marshes of Ruby Lake National Wildlife Refuge, Nevada.*

In the spring, canvasbacks radio-marked in Task 1 will be followed back to Ruby Lake for the breeding season. One egg will be randomly collected from each nest for contaminants analysis, and the hatching and fledging success of each nest evaluated. Nesting success will be compared to contaminant concentrations in eggs and winter foraging locations as determined by telemetry. If feasible, female ducks will have blood samples taken as the breeding season progresses to determine mercury and selenium depuration rates. Forage and prey items from the refuge will be collected to evaluate background concentrations of contaminants.

Productivity will be evaluated relative to the estimated risk of exposure, measured contaminant concentrations in field collected canvasbacks on the bay, and contaminant concentrations in randomly collected eggs. Although the potential exposure of canvasbacks is less because they prefer to consume primarily vegetation, loss of vegetative foods in the estuary has resulted in their increased consumption of animal prey, and mercury and selenium have been detected in increasing concentrations in canvasback livers from the bay (Miles and Ohlendorf 1993). Also, this species is the only diving duck wintering in San Francisco Bay that has an accessible breeding population in close proximity to its wintering area.

Task 5. *Examine the toxicological significance of field results with laboratory dosing studies using mallard ducks.*

The use of a laboratory dosing study will greatly strengthen the conclusions that can be drawn from the field studies. In the laboratory the influences of other variables, such as weather, food supply, and disease will be controlled for. By having control over the concentrations of mercury, selenium, and cadmium to which adults and their eggs are exposed it will be possible to estimate No Observed Adverse Effect Levels for each element and study the interactions among the three.

Because the laboratory studies will include a complicated interaction experiment with many treatment groups, mallards (*Anas platyrhynchos*) of proven breeding ability will be used. The use of proven breeders will reduce variation and, therefore, enable sample sizes for each treatment to be modest but still provide adequate statistical power. In the first year, 200 pairs of one-year-old mallards will be taken through a reproductive season on a control diet. Twenty eggs will be collected from each pair and set in an incubator.

The pairs having the highest hatching success of eggs will be saved for the second year. In the second year, 10 pairs of mallards will be randomly assigned to each of the following eight dietary treatments: controls, mercury, selenium, cadmium, mercury plus selenium, mercury plus cadmium, selenium plus cadmium, and mercury plus selenium plus cadmium. The forms of each element will be methylmercury chloride, seleno-DL-methionine, and cadmium chloride. The dietary concentration of each element will be selected based on the concentrations found in the food items collected in Task 2 and in the canvasback eggs collected from Ruby Lake National Wildlife Refuge.

Data collection and statistical analyses will be similar to those used in previous mercury and selenium reproductive studies by Heinz (1979), Heinz et al. (1989), Heinz and Hoffman (1996), Heinz and Hoffman (in press), and Hoffman and Heinz (1988). The health of the adult breeders will be followed, as well the fertility and hatching success of eggs, survival and growth of young, and teratogenic and physiological effects. Concentrations of mercury, selenium, and cadmium in adult livers, blood, and (in the case of cadmium) kidney will be measured. One egg from each female also will be analyzed for each of the three elements. Residues of mercury, selenium, and cadmium in adult tissues and eggs will be related to adult health and reproductive success in the laboratory study and to residues and effects seen in Tasks 3, 4, and 6 in the field. Physiological effects will include interactions of Se and Hg as related to glutathione status, related enzymes and oxidative stress previously reported in experimentally treated mallards (Hoffman and Heinz, in press) and in diving ducks in San Francisco Bay (Hoffman et al., in press).

In the third year, egg injection studies will be used to estimate No Observed Adverse Effect Levels of mercury, selenium, cadmium, and combinations of the three elements in eggs. First, eggs will be injected with the concentrations of mercury, selenium, and cadmium found in the mallards eggs from the dietary study in the second year. Hatching success of the eggs, teratogenic and physiological effects, and survival of young will be compared with the results of the second year, when the elements were put into the egg by the mother. Then, various concentrations of each element, by itself or in combination, will be injected until a no effect level is determined. The use of the egg injection technique will greatly reduce the effort and cost, compared to dietary tests with adult breeders, needed to estimate No Observed Adverse Effect Levels of the three elements in eggs.

Task 6. *Determine whether blood sample analyses can be used as a reliable non-lethal screen for contaminant exposures correlated to adverse effects in waterfowl.*

Future monitoring studies will be greatly enhanced if non-lethal blood collection and analysis can be used to determine exposure to contaminants of concern and estimate the potential for adverse effects in waterfowl. Data collected in Tasks 1-5 will be specifically evaluated to determine the efficacy of relating blood contaminant concentrations to concentrations in other tissues, eggs, and diet; and correlating blood concentrations with observed adverse effects. Development of a non-lethal screen is particularly important for future studies that assess contaminant effects on endangered species in the estuary.

B. Location and/or Geographic Boundaries

This study will be conducted primarily in Sonoma and Solano Counties, with field work in San Pablo and Suisun Bays, Sacramento-San Joaquin Delta, Sacramento River watershed. However, due to the breeding ecology of canvasback ducks, evaluation of their migratory and reproductive success will be made in the Ruby Lake National Wildlife Refuge in Nevada. The laboratory component will be conducted at the Patuxent Wildlife Research Center in Laurel, Maryland.

C. Expected Benefits

The data collected in this study will enable better evaluation of permissible levels of discharge for cadmium, mercury, and selenium, and assist in determining relative priorities in the control of these pollutants entering the bay through permitted and unpermitted discharges. The information provided on contaminant concentrations and effects in different portions of the estuary will enable the multi-agency San Francisco Bay Area Wetlands Ecosystem Goals Project and CALFED to identify areas where direct management options for improving habitats and water quality in the estuary are most feasible. The results will also be used to evaluate or determine clean up levels for numerous CERCLA sites around the margins of San Francisco Bay. Risks of contaminant effects on other benthic foragers such as clapper rails and green sturgeon can be better assessed and focused studies developed. Lastly, the study will provide an assessment of baseline risks of current contaminant inputs to the delta for species at greatest hazard, enabling the effects of CALFED alternatives to be monitored after they are implemented.

D. Background and Biological/Technical Justification

The San Francisco Bay ecosystem is one of the largest estuaries on the Pacific coast of North America (Conomos 1979) and the major water source for a large proportion of California. The estuary also is a major wintering area for waterfowl populations. More than 700,000 waterfowl are counted in the estuary during the mid-winter surveys (U.S. Fish and Wildlife Service, unpubl. data), and an estimated 300,000 waterfowl have used the open bays and salt ponds alone (Accurso 1992). During the winter, the estuary supports half the diving duck population and most of the canvasbacks in the Pacific flyway (Rienecker 1985). It also provides sanctuary for many other species of waterbirds, including the largest community of wintering and migrating shorebirds on the west coast (Kjelmyr *et al.* 1991).

The natural wetlands of San Francisco Bay ecosystem have been diked or degraded for agricultural, municipal, and industrial uses beginning in 1850 (Ver Planck 1958, Nichols *et al.* 1986). A recent agreement between the federal government and the state of California identified the crisis in the estuary between human and wildlife needs through a proposed planning process (CALFED) that would continue providing municipal water, maintain the levee system, and manage for the natural resources of the estuary. However, few studies have been conducted in the northern region of the ecosystem to address the water quality concerns with relation to the large migratory bird populations. Additionally, introductions of exotic species such as the Asian clam (*Potamocorbula amurensis*) have changed available food resources for migratory birds. Recent studies indicate that the Asian clam is increasing exponentially in the North Bay area and it has higher levels of contaminants than native species, effectively tripling the concentration of selenium in shellfish (Luoma and Linville 1995). Miles and Ohlendorf (1993) and Ohlendorf *et al.* (1986) have reported elevated contaminant levels in diving ducks, heavily dependent on shellfish and widely distributed in the San Francisco Bay ecosystem, including canvasbacks (*Aythya valisineria*), lesser and greater scaup (*A. affinis*, *A. marila*), and surf scoters (*Melanitta perspicillata*), suggesting that contaminants are biomagnifying in the food chain.

Numerous toxic hot spots have been documented in the San Francisco Bay ecosystem (Citizens for a Better Environment 1987), and a recent environmental review of refineries in California noted that refineries in the north San Francisco Bay as the greatest polluters in the state (San Francisco Examiner, May 1997). The San Francisco Bay ecosystem has enriched inputs of both mercury and selenium. North Bay mercury inputs from abandoned mines, disturbed geological deposits and thermal hot springs in the coast range, water treatment plant discharges in Sacramento, and erodible deposits of elemental mercury left in Sierra Nevada streams during the Gold Rush Era are estimated in the hundreds of kilograms per year. Selenium inputs of 3,632 kilograms selenite per year result from the refining of San Joaquin crude oil

on the eastern edge of San Pablo Bay and in Carquinez Strait. Irrigation drainwater and the erosion of Cretaceous marine shales from the west side of the San Joaquin Valley annually provide another 7,264 kilograms of selenium as selenate via the San Joaquin River. CALFED alternatives might greatly affect the latter, which is now predominantly either pumped south or lost in the delta.

Mercury and selenium are often regarded as being toxicologically antagonistic, with the result that exposure to one of these elements protects individuals from the toxic effects of the other (El-Begearmi *et al.* 1977). However, several significant exceptions to this rule have emerged with regard to avian reproduction, and it seems that enhanced storage of both compounds might negate the protective benefits. Beijer and Jernelov (1978) reported that elevated selenium causes increased retention of mercury. Similarly, Hoffman and Heinz (in press) reported that elevated mercury causes increased retention of selenium. The livers of male mallards fed 10 ppm selenium had mean selenium concentrations of 9.6 ppm; livers of those birds fed 10 ppm selenium and 10 ppm mercury had mean selenium concentrations of 114 ppm. More importantly, Heinz and Hoffman (in press) found additive effects of mercury and selenium on avian teratogenesis and embryo mortality.

These reports, combined with the recent rise of *Potamocorbula* as the most dominant bivalve in the North Bay (Luoma and Linville 1995), may have created an environment causing adverse effects in diving ducks and other migratory birds. Ohlendorf *et al.* (1986) reported selenium concentrations of 64.2 ppm in January and 74.8 ppm in March in the livers of surf scoters from San Pablo Bay. Selenium and mercury concentrations in scoters and other species are likely to be approaching the levels at which reproduction has been shown to be impaired in captive studies.

Recently, a multi-agency project known as the San Francisco Bay Area Wetlands Ecosystem Goals Project (EPA, unpubl. report) was initiated to provide a planning document for natural resources in the estuary. One objective of the project is to provide recommendations for adaptive management to create or restore migratory bird habitats in the ecosystem. These recommendations will incorporate information on contaminant risks in the estuary from studies such as this proposed project on diving ducks, and will provide direct management options for improving habitats in parts of the estuary with lower contaminant levels.

E. Proposed Scope of Work

Tasks 1-6 will be performed using an integrated schedule over a four year period as follows:

FY 98 Fall - Capture and radio-marking of scaup and scoters in San Pablo and Suisun Bays.

Winter - Weekly tracking of radio-marked birds. Purchase mallards for laboratory study.

Spring - Identification of core sampling grids. Conduct the first phase of the mallard laboratory study.

Summer - Capture and radio-marking of female canvasback ducks at Ruby Lake National Wildlife Refuge.

FY 99 Fall - Following migration of canvasbacks from Ruby Lake to San Francisco Bay, capture and radio-marking of additional scaup and scoters; late fall collection of cores and ducks for chemical and stomach content analyses; status report for FY 98.

Winter - Continued weekly tracking of radio-marked ducks; late winter collection of cores and ducks for chemical and stomach content analyses. Begin feeding mallards dietary concentrations of mercury,

selenium, and cadmium.

Spring - Tracking of radio-marked female canvasbacks to Ruby Lake; collection of eggs and monitoring of nesting and fledging success. Collect reproductive data from mallard laboratory study.

Summer - Capture and marking of additional female canvasbacks; preparation of interim report. Conclude data collection in laboratory study.

FY 00 Fall - Tracking canvasbacks to San Francisco Bay, late fall collection of cores and ducks for chemical and stomach content analyses; status report for FY 99.

Winter - Continued weekly tracking of radio-marked canvasbacks; late winter collection of cores and ducks for chemical and stomach content analyses.

Spring - Tracking of radio-marked female canvasbacks to Ruby Lake; collection of eggs and monitoring of nesting and fledging success. Begin egg injection studies.

Summer - Complete egg injection studies. Submit the last of samples for mercury, selenium, and cadmium analyses.

FY 01 Fall - Data and chemical analyses; status report for FY 00.

Winter - Data and chemical analyses.

Spring - Data and chemical analyses.

Summer - Final report preparation.

FY 02 Fall - Complete final report

Status reports will be submitted annually in the fall of years 1-3 of the study, prior to allocation of the following year s funding. The final report due in the fall of year 4.

F. Monitoring and Data Evaluation

The investigators will participate in integrated semi-annual workshops with other CALFED project investigators examining mercury contamination in the Sacramento-San Joaquin system to review and share preliminary data. In addition, status reports, prepared in cooperation with other investigators, will be submitted at the end of years 1-3 of the study. Data will be evaluated and analyzed using standard parametric and nonparametric techniques as appropriate. The final report will be submitted to a peer reviewed journal for publication, with the final report prepared in the format of the target journal.

G. Implementability

The project is fully implementable under the terms of current scientific collecting permits held by the Biological Resources Division of the U.S. Geological Survey and the U.S. Fish and Wildlife Service investigators.

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IV. COSTS AND SCHEDULE TO IMPLEMENT PROPOSED PROJECT

A. Budget Costs

The specific costs and funding source for each project task are provided in Table 1.

Table 1. Project Cost Summary by Task.

Project Phase and Task	Direct Labor Hours	Direct Salary and Benefits	Overhead Labor (General, Admin and fee)	Service Contracts	Material and Acquisition Contracts	Miscellaneous and other Direct Costs	Total Cost
Task 1 CALFED; no O&M	7,142	106,654	36,037	19,200	14,400	124,800	307,815
Task 2 CALFED; no O&M	3,780	66,494	12,815	0	0	8,400	91,071
Task 3 CALFED; no O&M	2,099	46,414	31,527	229,900	0	4,200	313,722
Task 4 CALFED; no O&M	3,780	66,494	14,159	0	0	19,600	103,615
Task 5 CALFED; no O&M	42,000	132,000	36,080	124,800	50,000	12,000	396,880
Task 6 CALFED; no O&M	418	26,334	6,584	0	0	0	32,918
Grand Total							1,246,021

CALFED funding is currently the only source of funding available to carry out this project; however, in-kind services (principal investigator salaries and benefits, facilities, and overhead) totaling $446,100 over four years will be provided by the U.S. Geological Survey, Biological Resources Division. Task 6, preparation of an integrative report that requires no additional data collection, will actually be conducted concurrently with Tasks 1 through 5 to the maximum extent possible, and will require little additional funding. It is also possible that the support of CALFED will facilitate the leverage of other partnerships, ultimately reducing the total cost to CALFED. Because this is a joint venture type project, work will be carried out by the cooperating agencies using in-house resources, and subcontracts will not be used; however, all cooperating agencies are required to comply fully with all Federal laws regarding labor, equal opportunity, worker health and safety, equal opportunity, etc. The U.S. Fish and Wildlife Service will be responsible for distributing and administering any funds that are granted. It is requested that project funding be provided on an annual basis beginning in Fiscal Year 1998 in accordance with the schedule indicated in B. Schedule of Milestones.

B. Schedule of Milestones

Most project tasks will be initiated the first year that funding is received and progress concurrently through the completion of data analysis, as indicated in Table 2.

Table 2. Project Schedule

Task	Start	Complete
1. Movement and over-winter survival of diving ducks	Fall 1997	Winter 2000
2. Foraging ecology and food preferences of over-wintering diving ducks	Spring 1998	Winter 2000
3. Contaminant concentrations in tissue of over-wintering ducks	Spring 1998	Winter 2000
4. Productivity of Ruby Lake canvasbacks	Summer 1998	Spring 2000
5. Mallard dosing study	Winter 1997	Spring 2001
6. Evaluation of non-lethal blood screening	Fall 1998	Spring 2001
Final Report	Summer 2001	Fall 2001

Table 3 outlines the proposed schedule of payments to support project implementation and execution and provides the annual breakdown of USGS in-kind services (approximately 35% of the amount requested from CALFED) for comparison:

Table 3. Proposed Schedule of Payment and Per Annum U.S. Geological Survey Cost Share (In-kind Services).

	FY 98	FY 99	FY 00	FY 01	TOTAL
CALFED	$279,610	$497,641	$378,061	$ 90,709	$1,246,021
USGS	$96,000	$125,600	$121,000	$103,500	$446,100

C. Third Party Impacts

There are no third party impacts associated with this project.

V. APPLICANT QUALIFICATIONS

A. JOHN TAKEKAWA

Dr. John Takekawa received his Ph.D. in Animal Ecology, with a minor in Statistics, from Iowa State University in 1987. His dissertation focused on the energetics of canvasbacks staging on an upper Mississippi River pool during fall migration. He has over 15 years experience as a research biologist with the U.S. Fish and Wildlife Service, the National Biological Service, and the U.S. Geological Survey, Biological Resources Division, and has received numerous awards from those agencies during the course of his career. He is active as a member of The Wildlife Society, the British Ornithologist s Union, and the American Institute of Biological Sciences. Dr. Takekawa currently heads the San Francisco Bay Estuary Field Station in Vallejo, California, under the auspices of the USGS California Pacific Science Center, where he has participated in four previous studies on waterfowl and shorebirds. Dr. Takekawa s publications include peer reviewed journal articles that specifically address the results of those studies.

B. KEITH MILES

Dr. A. Keith Miles obtained his Ph.D. from Oregon State University in Wildlife Ecology. He is currently employed as a research biologist by the Biological Resources Division of the U.S. Geological Survey. His primary focus of research is on the effects of contaminants on estuarine and marine habitats, particularly prey organisms of waterfowl and marine mammals under trust to the United States Government. Dr. Miles emphasis is to determine consequences of accumulation of contaminants in prey, and discriminate effects caused by contaminants from naturally occurring changes in prey populations. Since 1987, he has conducted studies on the effects of contaminants on the structure or dynamics of invertebrate or vegetative assemblages, and the potential for accumulation of these contaminants among prey guilds and their migratory bird or marine mammal predators. His studies have been conducted at Chesapeake Bay, and currently at San Francisco Bay and the Arctic environment. He has worked in cooperation with the U.S. Fish & Wildlife Service, U.S. Navy, and the California Department of Parks and Recreation. He is primary author on 6 scientific journal articles on environmental contaminants, and primary author or co-author on 9 other related articles published or pending publication.

C. JAMES HAAS

Mr. James Haas received his B.S. in Wildlife and Fisheries Resources from the University of Idaho in 1974, and his master s degree in Biology from San Francisco State University in 1995. His master s thesis examined waterfowl use of grazed and ungrazed seasonal wetlands in northern San Pablo Bay. Since 1992 Mr. Haas has worked for the U.S. Fish and Wildlife Service in the Sacramento Field Office, Environmental Contaminants Division, where he has conducted or participated in natural resource damage assessments for chemical releases, oil spill response activities, restoration planning, ecological risk assessments, and general contaminants investigations throughout northern California. Prior to his employment with the USFWS, Mr. Haas served as the Environmental Coordinator at Naval Air Station, Moffett Field, California, responsible for managing all aspects of the station s environmental compliance program, including Superfund cleanup, hazardous waste management, Clean Air and Clean Water Act compliance, and natural and cultural resources management. There he supervised an interdisciplinary staff of 13 personnel, with an annual budget of over 1 million dollars. In recognition of his performance on behalf of the station, Mr. Haas was awarded the prestigious Department of the Navy Meritorious Civilian Service Medal. Through his education and work experience, Mr. Haas has developed an active professional and personal interest in the ecology of the San Francisco Bay estuary.

D. STEVEN SCHWARZBACH

Dr. Steven Schwarzbach received his Ph.D. in Ecology from the University of California at Davis in 1989. He currently serves as the chief of the Environmental Contaminants Division of the Sacramento Field Office, USFWS. He has designed and directed numerous multidisciplinary field studies of environmental contaminant impacts to fish and wildlife in California including studies in the Klamath Basin, Sacramento Valley, Tulare Basin, San Luis Refuge Complex, and intertidal marshes of San Francisco Bay. Contaminant studies in which Dr. Schwarzbach has been involved have focused on mercury, selenium, organophosphate pesticides, aquatic herbicides, organochlorines, trifluoracetic acid, acid mine drainage, ammonia, and eutrophication effects upon water quality. Dr. Schwarzbach supervises a staff of 10 permanent biologists and administers a 1.4 million dollar a year budget. His personal scientific interests have most recently been particularly focused on mercury and selenium in birds of the San Joaquin Valley and San Francisco Bay.

E. GARY HEINZ

Dr. Gary Heinz received his Ph.D. in Wildlife Biology from Michigan State University in 1969. Since then he has gained nearly 30 years experience as a Research Biologist, studying environmental contaminants, with the U.S. Fish and Wildlife Service, National Biological Service, and U.S. Geological Survey. Dr. Heinz has published over 60 book chapters and publications in peer reviewed journals dealing with the effects of environmental contaminants on wildlife. Over 30 of these publications deal with the effects of mercury, selenium, or cadmium on wildlife.

E. DAVID HOFFMAN

Dr. David Hoffman received his Ph.D. in Developmental Zoology and Physiology, from the University of Maryland in 1971. He has been employed as a Postdoctoral Fellow in the Oak Ridge National Laboratory Biochemistry Section, as a Senior Staff Physiologist in the U.S. Environmental Protection Agency Health Effects Research Laboratory, Cincinnati, OH, and since 1976 has been a Research Physiologist, studying environmental contaminants, with the U.S. Fish and Wildlife Service, National Biological Service, and U.S. Geological Survey. Research areas include avian teratology, physiological stress and contaminant interactions. Dr. Hoffman is also an Adjunct Professor in the Biology Department of the University of Maryland at Frostburg. He has published over 80 book chapters and publications in peer reviewed journals dealing with the effects of environmental contaminants on wildlife. Approximately half of these publications deal with the effects of metals or metal interactions including mercury and selenium on wildlife.

Specific responsibilities of the cooperating investigators are outlined as follows:

Name	Project Management	Technical	Administrative
Dr. John Takekawa	X	X	X
Dr. Keith Miles		X	
Mr. Jim Haas		X	X
Dr. Steve Schwarzbach	X	X	
Dr. Gary Heinz	X	X	
Dr. David Hoffman		X	

There are no potential conflicts of interest.

VI. Compliance with Standard Terms and Conditions.

The financially responsible applicant is a representative of a federal agency, the U.S. Fish and Wildlife Service. The Fish and Wildlife Service agrees to comply with terms and conditions to the extent allowed by federal law. It is the applicant s understanding from table D of the RFP that no supplemental forms are required of federal agencies at the time of proposal submittal.